INTERNATIONAL ATOMIC ENERGY AGENCY
UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION
INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS
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SMR.780 - 7

FOURTH AUTUMN COURSE ON MATHEMATICAL ECOLOGY

(24 October - 11 November 1994)

"Spatial Analysis: A Case Study of Forest Landscape Dynamics"

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Spatial analysis: A case study of forest landscape dynamics

Gap, transition models and GIS

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Readings

- On gap-models:
  - Urban D.L. and H.H. Shugart. 1992. Individual-based models of forest succession. pp: 249-292. In: Glenn-Lewin, R.K. Peet and T.T. Veblen (Eds.) *Plant Succession: Theory and prediction*. Chapman and Hall.
- On forest landscape dynamics:
  - Acevedo M.F., D.L. Urban and M. Ablan. 1994. Landscape scale forest dynamics: GIS, gap and transition models. GIS World. In press.

Outline

- Scaling-up: from gap models to semi-markov models
  - Functional roles
  - Canopy layers
- Linking GIS and semi-markov models
  - MOSAIC prototype
  - Adjusting parameters by cell conditions
- Application to HJA, Oregon

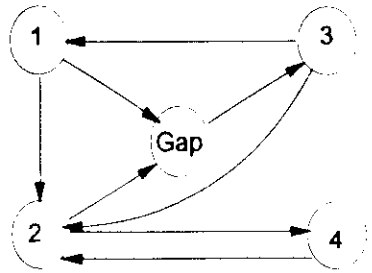
Modeling Approaches to Forest Dynamics

Gap Models		Transition Models
- Detailed Simulations		- Analysis
- Growth Dynamics		- Replacement dynamics
- Limiting Factors and Rules		- Markov models
Small Plots (ca 1/10 ha)	→	Aggregate of small plots (ca 10 ha)
Many runs		One run

Functional Roles

	Large	Small
Shade Intolerant	Role 1, Produces gaps Requires gaps	Role 3, Doesn't produce gaps Requires gaps
Shade Tolerant	Role2, Produces gaps Doesn't require gaps	Role 4, Doesn't produce gaps Doesn't require gaps

Transition graph for functional roles



ZELIG parameters for functional roles

	Age	Dm	Ht	G	F	GDDs		L	M	N	Sd	Sp
Role 1	300	200	45	500	9	2535	4535	4	6	2	3	0
Role 2	500	200	40	200	9	2535	4535	2	4	1	1	0
Role 3	100	35	15	1000	9	2535	4535	5	7	3	5	0
Role 4	200	35	15	150	9	2535	4535	1	4	1	1	0

SEMI-MARKOV MODEL

Time delays for holding time densities
Accounts for longevity and growth rate

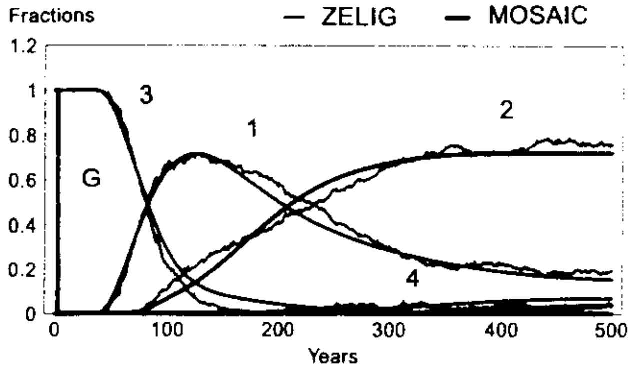
Delays: distributed and discrete

For distributed use gamma density

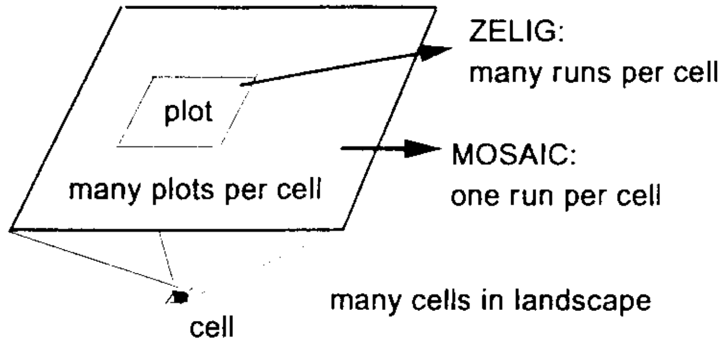
$$h(t) = d^{k}\, t^{k-1} \exp(-d\, t) / (k-1)!$$

t = time
k = order
d = rate

Cell Dynamics
Functional Roles



From gap to landscape



TERMS

CELL : mosaic of gap-scale plots

STATE OF A CELL: fraction of total area in each cover type

CELL DYNAMICS:
changing proportions of cover types

LANDSCAPE DYNAMICS:
changing states of a collection of cells

Transition Model Parameters

Terrain characteristics in GIS files determine cell conditions:
- slope/aspect (radiation)
- elevation (temp and precip)
- soil type

Transition parameters are adjusted by cell environmental conditions:
- soil moisture
- soil nutrients
- temperature

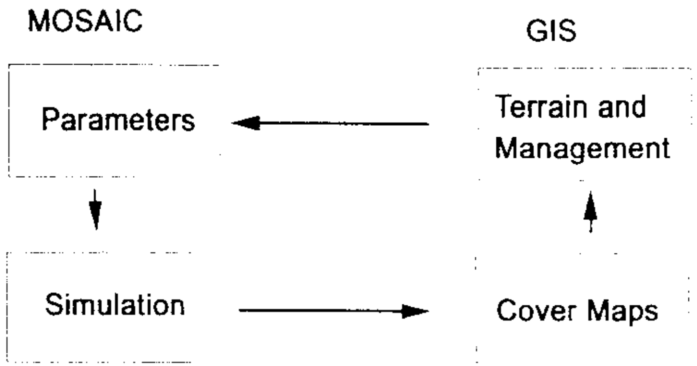
Adjusting transition parameters: cell environmental condition

For each transition:

cell_cond =
thermal_factor *
soil moisture_factor *
soil fertility_ factor

prob = prob * f(cell_cond)
rate = rate * g(cell_cond)
delay = delay * h(cell_cond)

GIS and MOSAIC



Model Performance

Depends on:
size of fixed delays,
order of gamma delays,
number transitions

For illustration:
delays order 5,
fixed delays 100 yrs,
10 transitions

SPARC 2
32 MB

500 yrs, 1000 cells : 30 min

MOSAIC prototype

Linked to GRASS by UNIX script:
- open monitors
- convert format
- pass parameters
- run model
- read results
- display maps

Species in HJA

Abies amabilis ABam Pacific silver fir

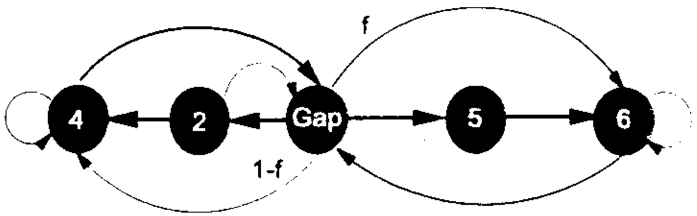
Pseudotsuga menziesii PSme Douglas fir

Tsuga heterophylla TShe Western Hemlock

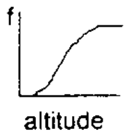
ZELIG parameters for species in HJA

	Age	Dm	Htm	G	F		GDD	L	M	N	Sds	Sp
ABAm	600	200	62.5	1250	1	118	1815	5	3	2	13.3	0
PSme	1100	300	84.1	1700	1	441	2411	2	4	2	13.3	0
TShe	500	225	63.6	1080	1	311	2480	5	3	2	13.3	0

Transition Graph for HJA



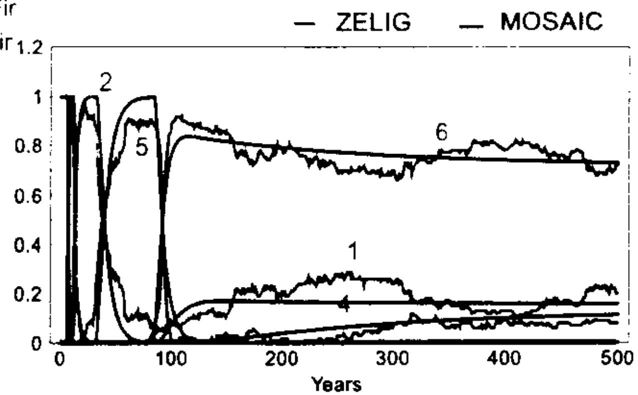
2 = Young Douglas Fir
4 = Mature Douglas Fir/ Hemlock



5 = Young True Fir
6 = Mature True Fir

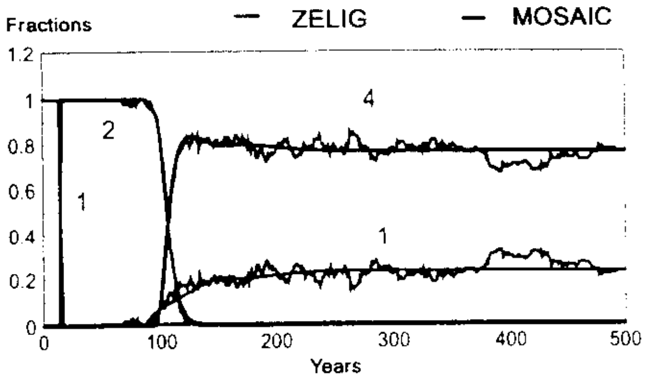
1 = GAP
2 = DFir
4 = DFir/Hem
5 = YTFir
6 = MTfir

Cell Dynamics HJA at 1200 m



1 = Gap
2 = DFir
4 = DFir/Hem

Cell Dynamics HJA at 500 m



Adjusting transition parameters: altitude in HJA

f(alt) = 1 / (1 + exp ((-alt + tone)/sens))

Prob (gap to 4) = 1- f(alt)
Prob (gap to 5) = f(alt)

delays = delays * g(alt)
rates = rates * h(alt)

Challenges

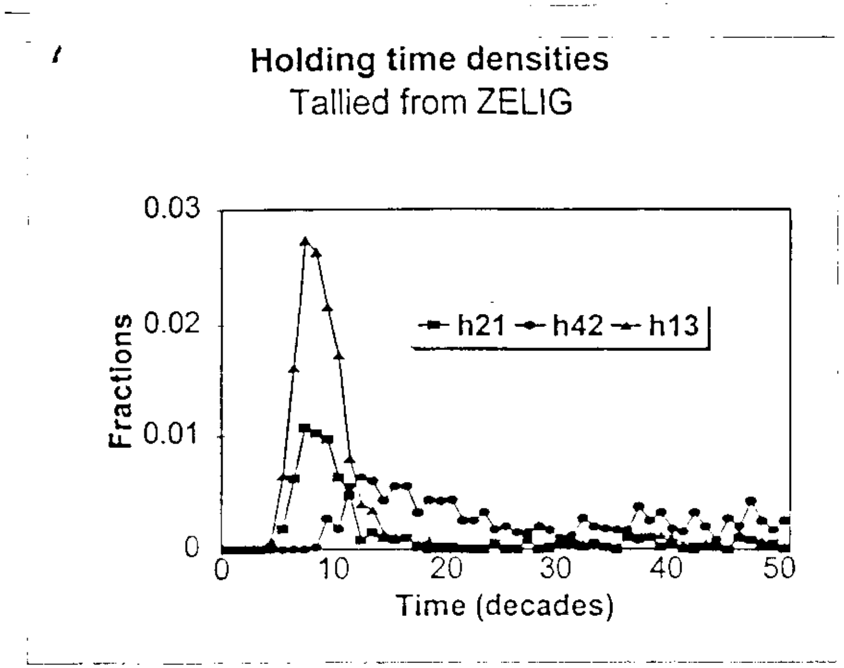
- Calibrate terrain effects on parameters
  - gradient in HJA 400 - 1600 m
  - soil types
  - remote sensing data
- Application to forest management practices in HJA
- Extend results to diverse forests
  - Characterize functional types

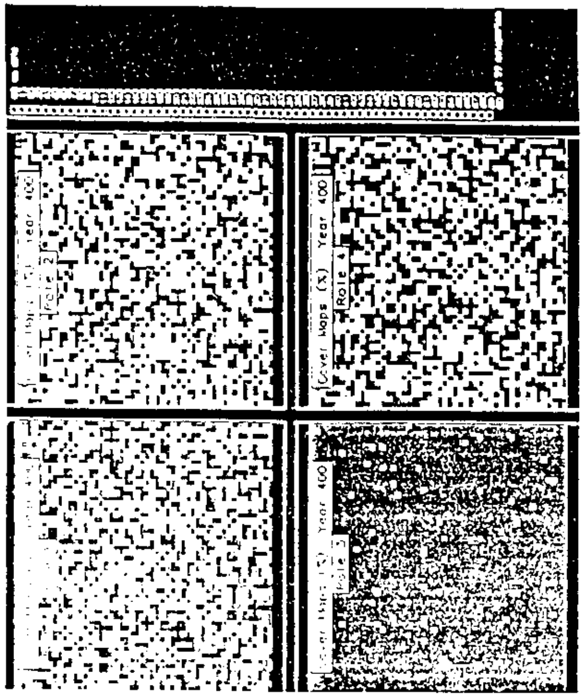
CONCLUSIONS

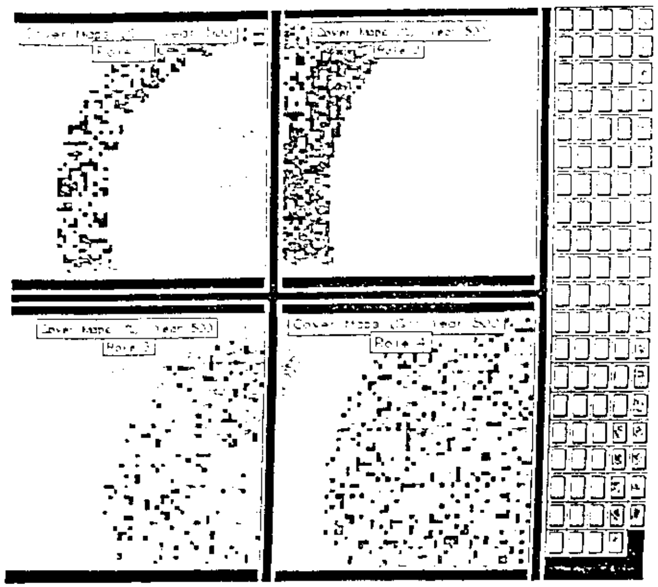
We want to look at the forest...

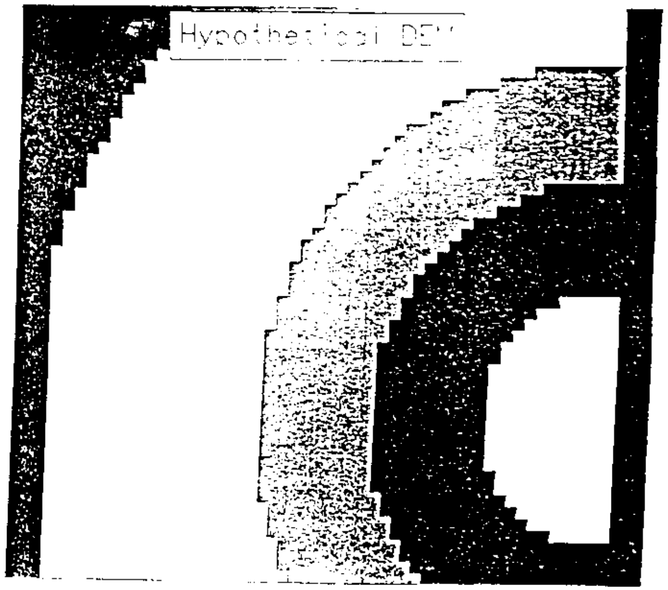
CONCLUSIONS

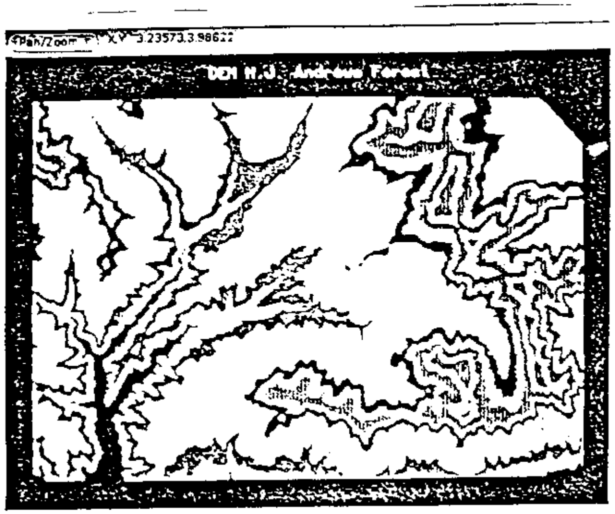
... but starting with the trees.

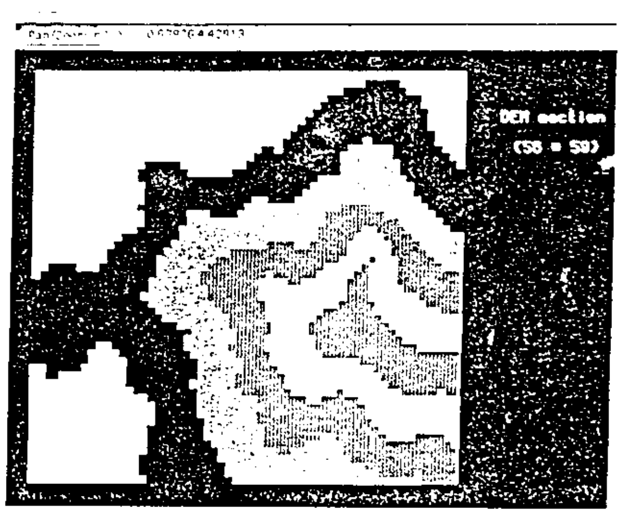

Holding time densities
Tallied from ZELIG
0.03
0.02
0.01
0
Fractions
h21
h42
h13
0
10
20
30
40
50
Time (decades)

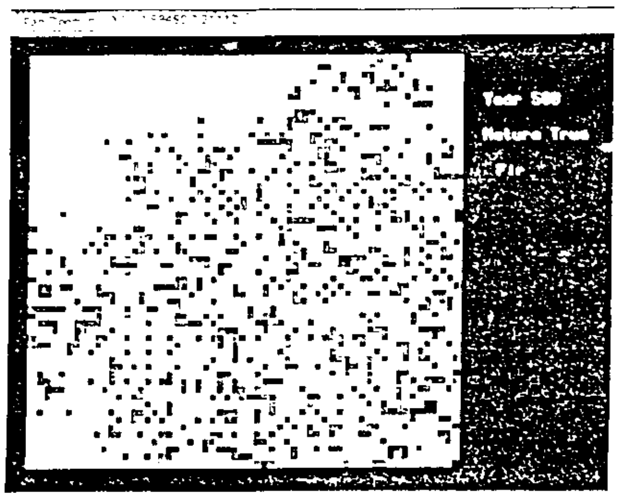


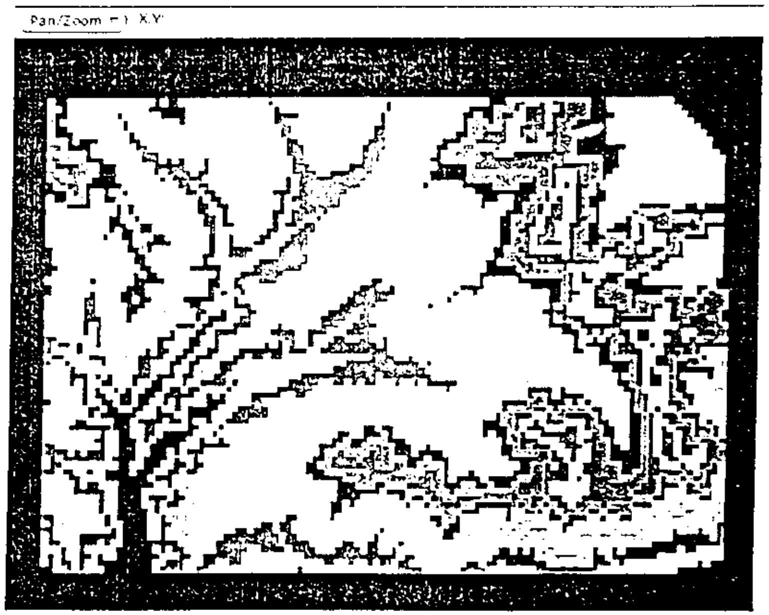




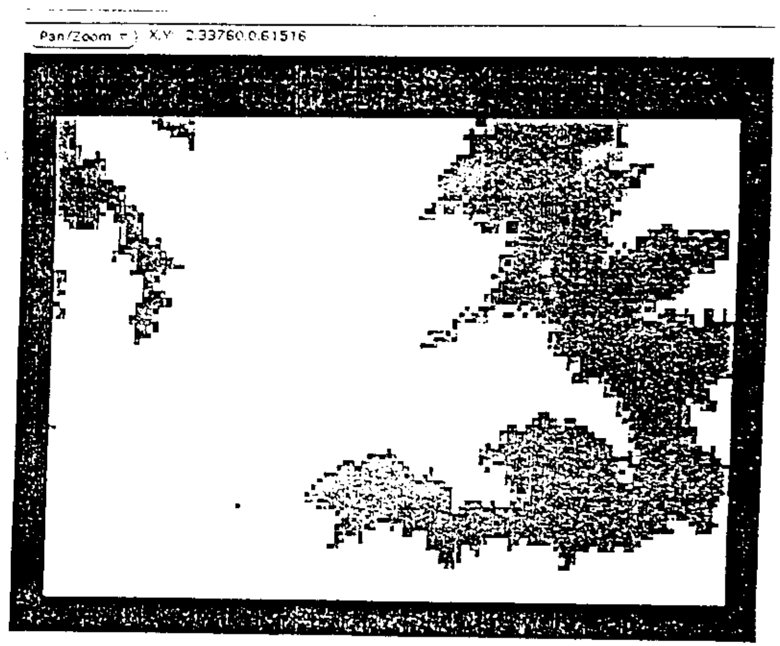

DEM H.J. Andrews Forest


DEM section


Mature Tree
Fir




Pan/Zoom X,Y: 3.11270,0.51673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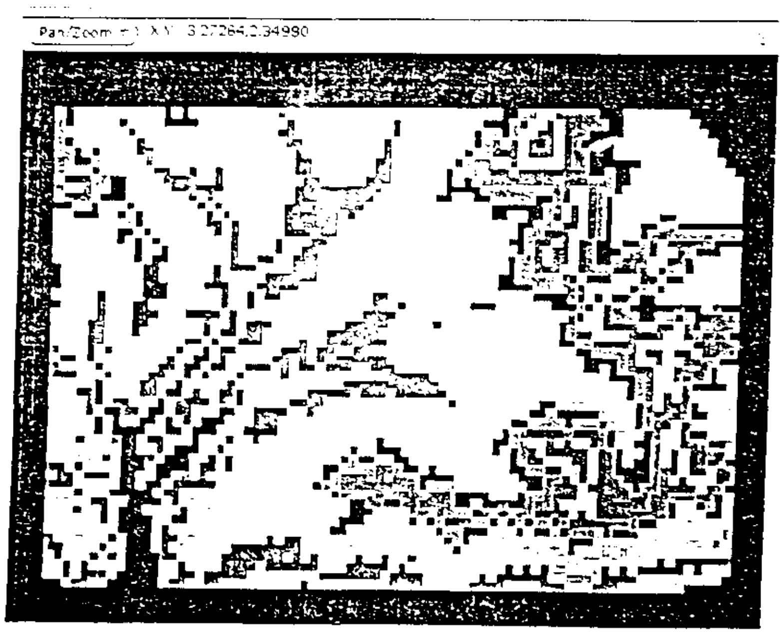
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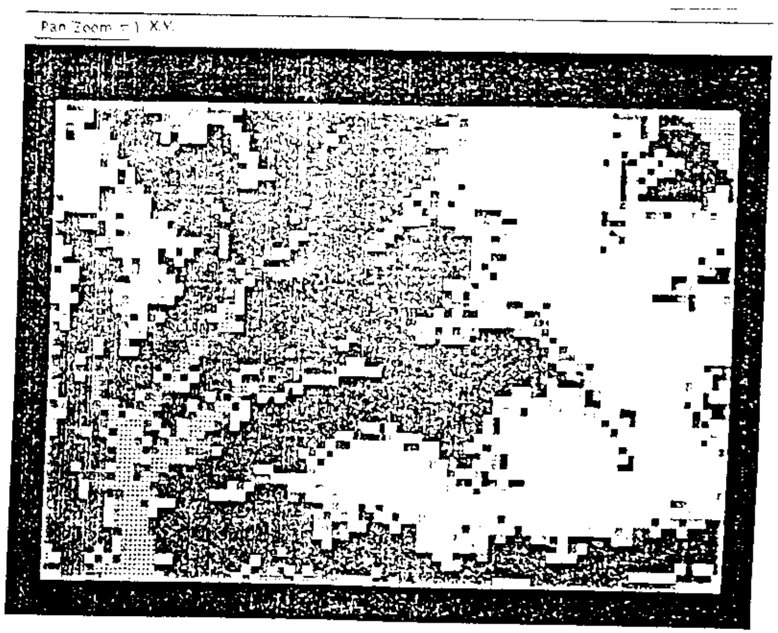
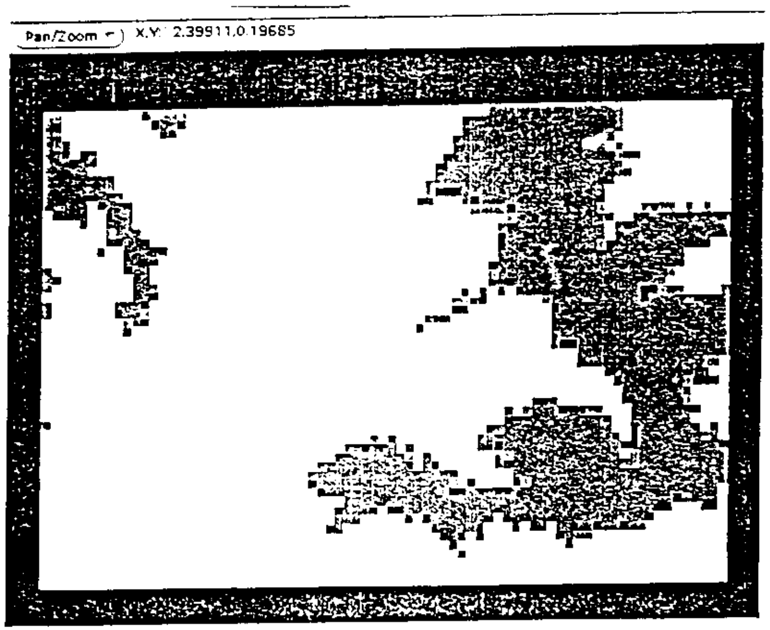

Pan/Zoom X,Y:


Pan/Zoom
X,Y: 2.39911,0.19685